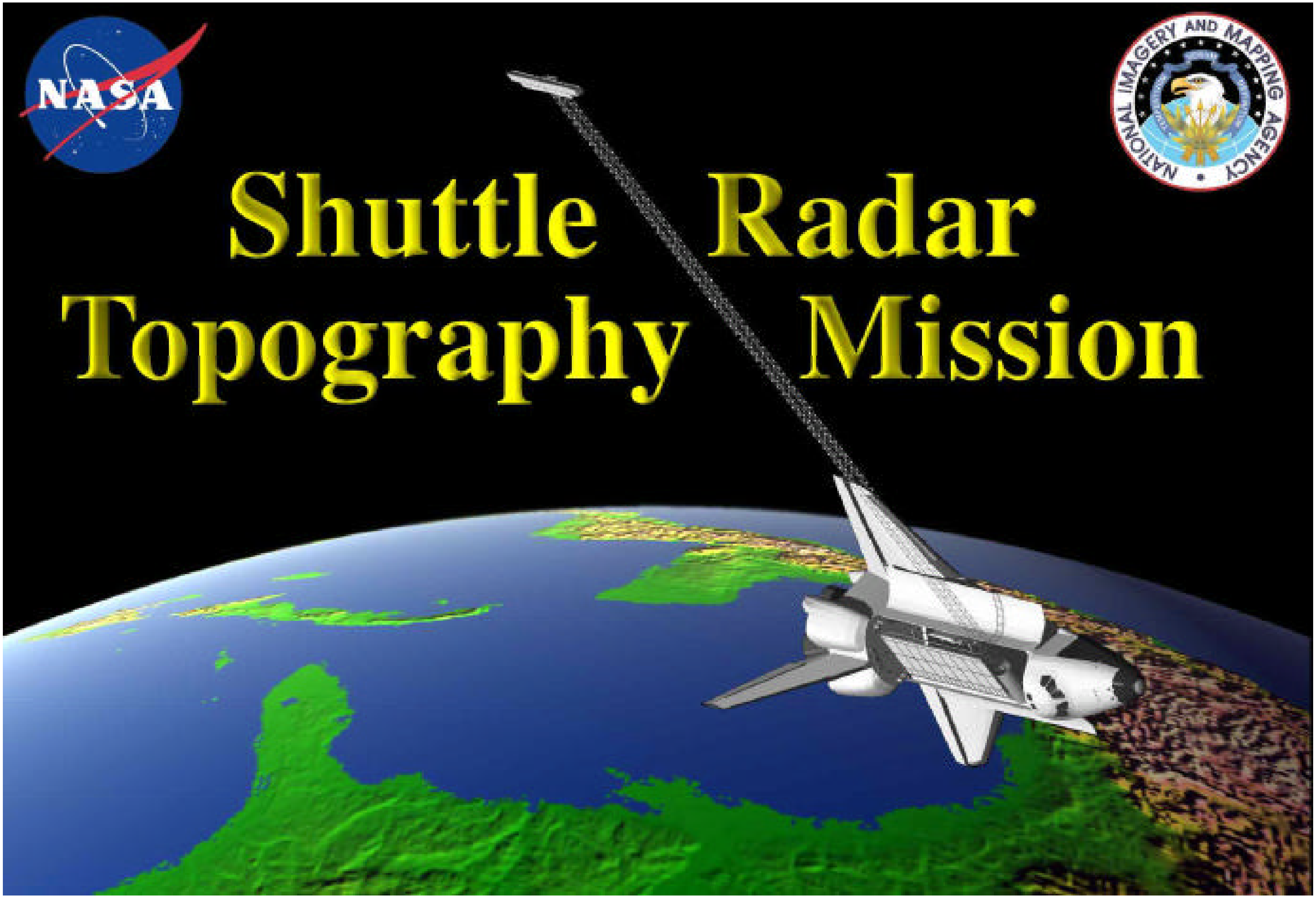
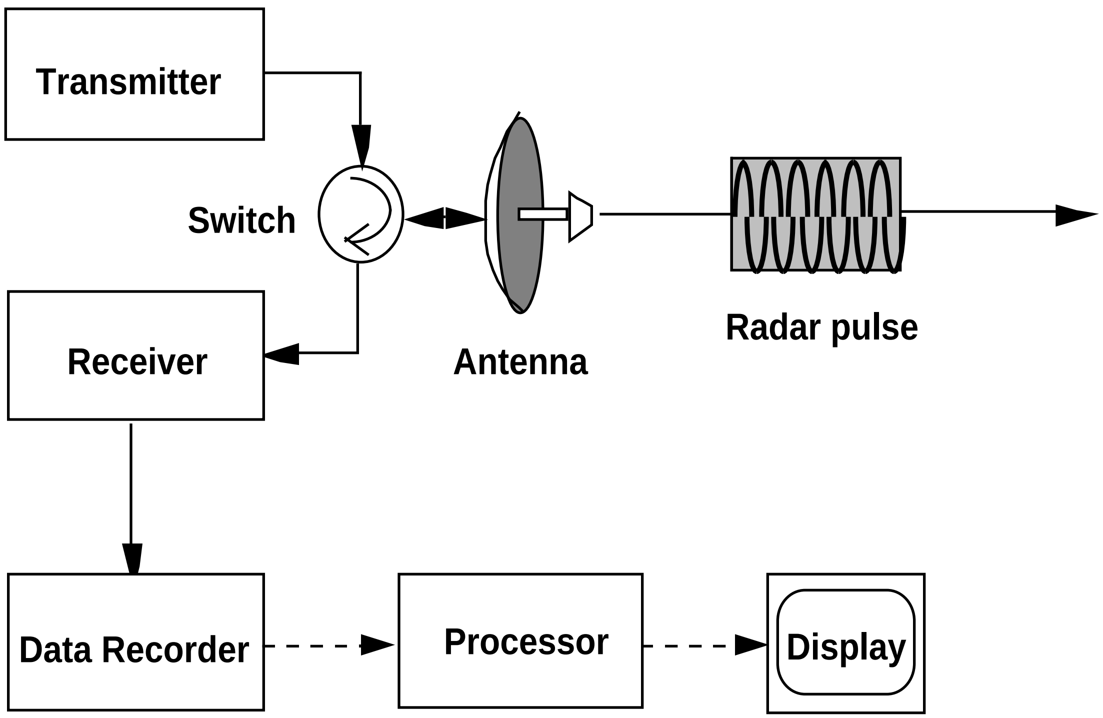

NASA
NATIONAL IMAGERY AND MAPPING AGENCY
Shuttle Radar
Topography Mission

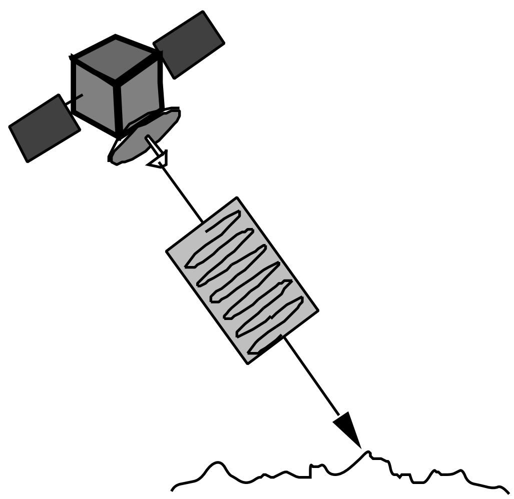
Imaging Radar Applications

- **HOW IMAGING RADAR WORKS**
  - **RADAR** = **RA**DIO **D**ETECTION AND **R**ANGING
  - RADAR WORKS LIKE A FLASH CAMERA AT RADIO WAVELENGTHS
  - BASIC RADAR SYSTEM DIAGRAM:

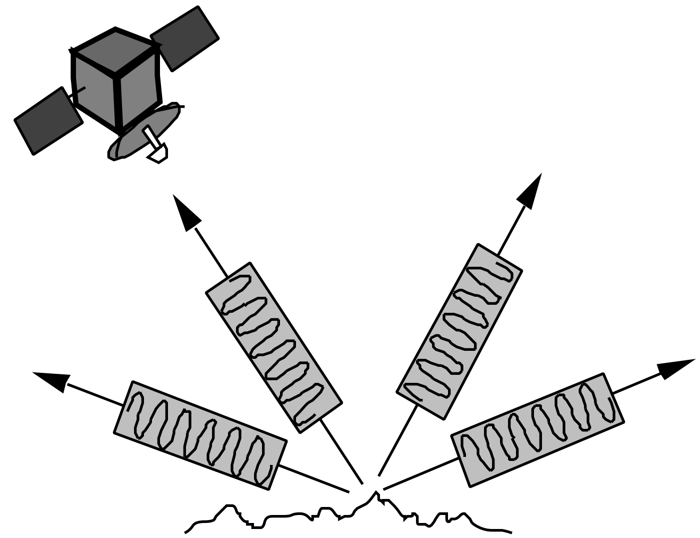


Imaging Radar Applications

- **RADAR MEASUREMENTS**



RADAR TRANSMITS A PULSE



MEASURES REFLECTED ECHO (BACKSCATTER)

1. Radar can measure time delay and strength of reflected echo
   ==> amplitude and phase measurements
2. Radar can only measure part of echo reflected back towards the antenna (backscatter)
3. Radar pulses travel at speed of light
4. Time delay ==> ability to image objects at different ranges from radar (range resolution)
5. Strength (amplitude) of reflected echo is called radar backscatter

- **POLARIZATION**

  - RADAR MEASUREMENTS CAN BE POLARIZED (USUALLY HORIZONTAL AND VERTICAL)

  - POLARIZATIONS ARE CONTROLLED BY SWITCHING BETWEEN H AND V ANTENNAS:

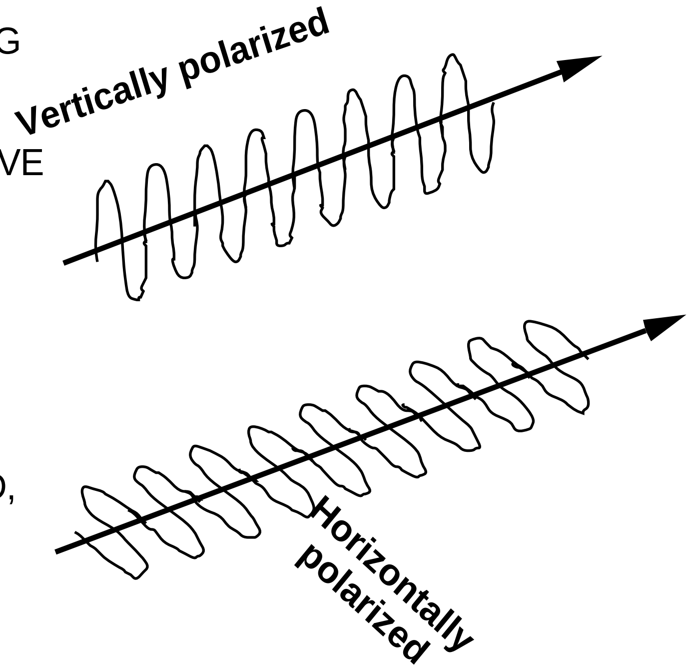
    HH = HORIZONTAL TRANSMIT, HORIZONTAL RECEIVE

    HV = HORIZONTAL TRANSMIT, VERTICAL RECEIVE

    VH = VERTICAL TRANSMIT, HORIZONTAL RECEIVE

    VV = VERTICAL TRANSMIT, VERTICAL RECEIVE

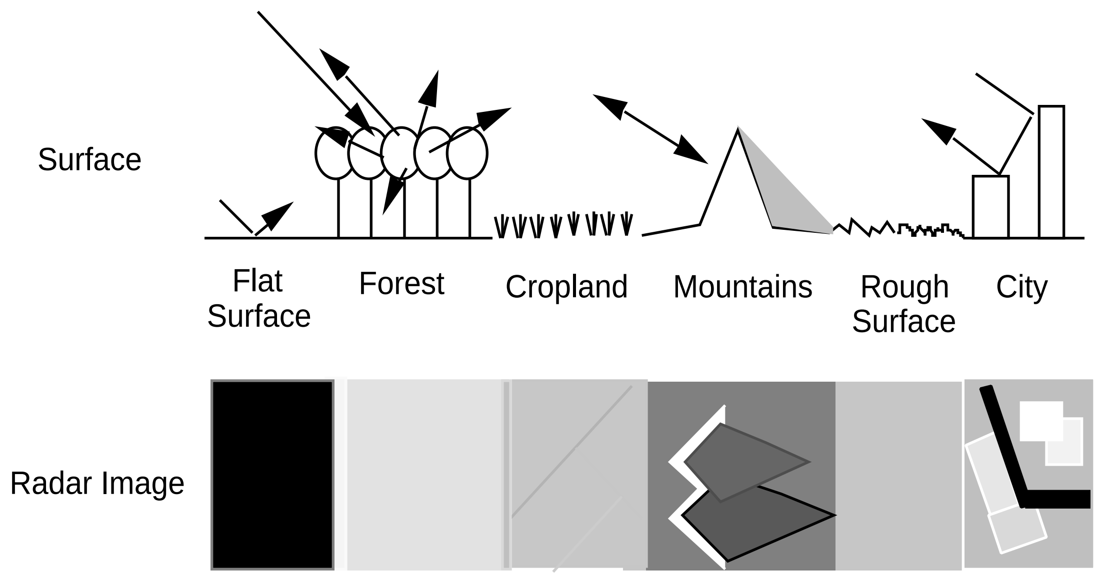
  - WHEN ALL FOUR POLARIZATIONS ARE MEASURED, RADAR IS IN 'QUAD-POL' MODE



  - POLARIZATION MEASUREMENTS CAN BE USED TO DETERMINE THE PHYSICS OF THE OBSERVED SCATTERING

Imaging Radar Applications

- **MORE ON RADAR MEASUREMENTS**
  - BACKSCATTER IS MEASURED IN UNITS OF AREA (RADAR CROSS SECTION OR RCS)
  - SCIENTISTS USE NORMALIZED RCS, OR S^o, WHICH IS DIMENSIONLESS (DECIBELS, dB)
  - S^o IS USUALLY BETWEEN -45 dB (VERY DARK) AND 0 dB (VERY BRIGHT)
  - SOME COMMON RADAR-SURFACE INTERACTIONS:



  - S^o DEPENDS ON SURFACE ROUGHNESS, STRUCTURE AND DIELECTRIC CONSTANT
  - S^o ALSO DEPENDS ON RADAR FREQUENCY, POLARIZATION, VIEWING ANGLES

Imaging Radar Applications

- **WHAT CHANGES RADAR MEASUREMENTS?**

  - RADAR BACKSCATTER DEPENDS ON:

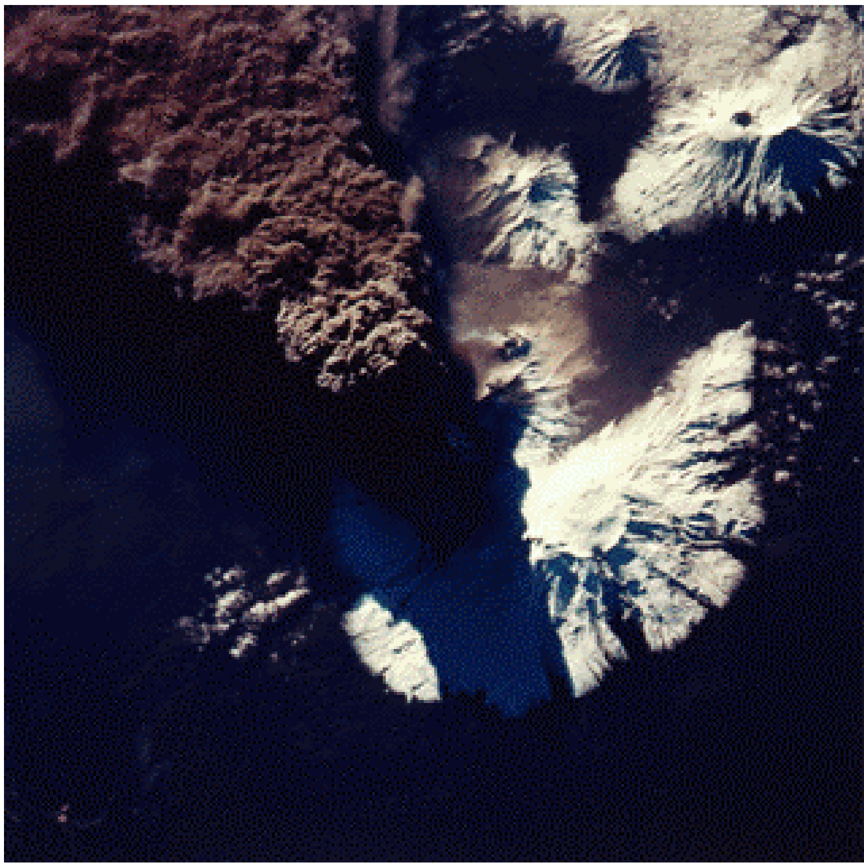
    - Radar Wavelength
    - Radar Polarization (Transmit And Receive)
    - Viewing Geometry (Incidence Angle And Azimuth Angle)
    - Surface Roughness
    - Structure Of Surface Or Objects Being Imaged
    - Surface Dielectric Constant (Often Related To Wetness Or Salinity)

  - SURFACE CHANGES OVER TIME THAT MAY AFFECT RADAR BACKSCATTER INCLUDE:

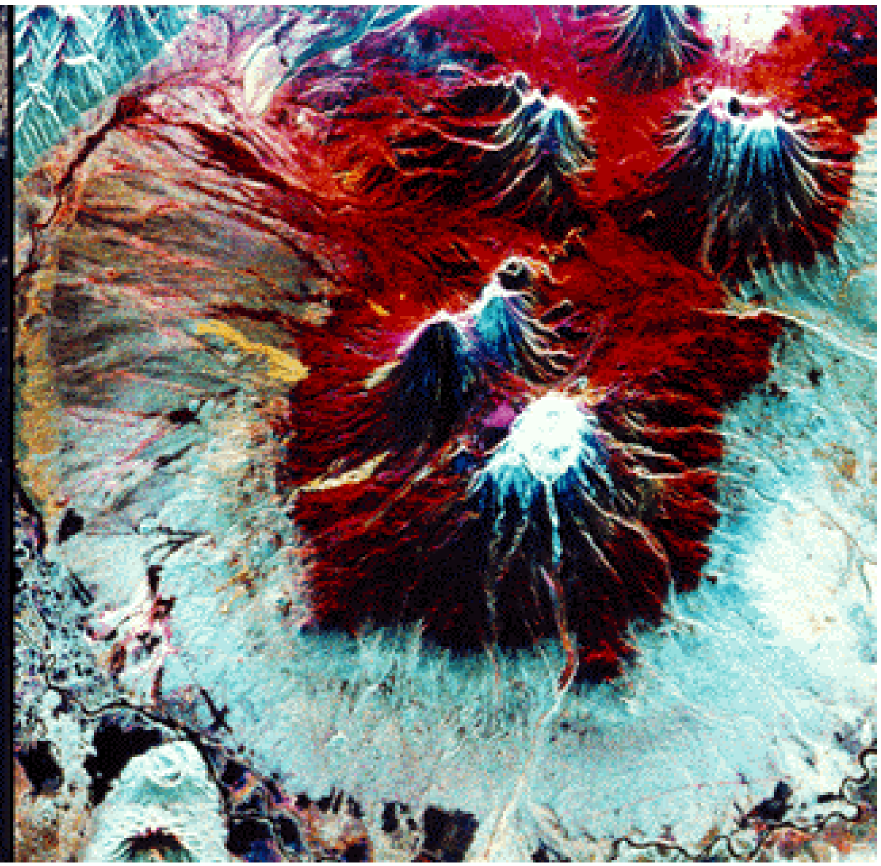
    - Flooding
    - Vegetation Growth And Leaf-Shedding
    - Environmental Damage To Vegetation, E.G. Forest Fires, Pollution
    - Logging
    - Changes In Surface Or Vegetation Moisture Content
    - Rain Storms
    - Freezing And Thawing (Changes In Moisture State And Surface Deformation)
    - Erosion
    - Surface Motion (Ocean, Sea-Ice And Glaciers)
    - Earthquakes
    - Swelling In Volcanically Active Regions
    - Land Subsidence

Kliuchevskoi Volcano, Kamchatka, Russia

September 30, 1994



Shuttle Photograph



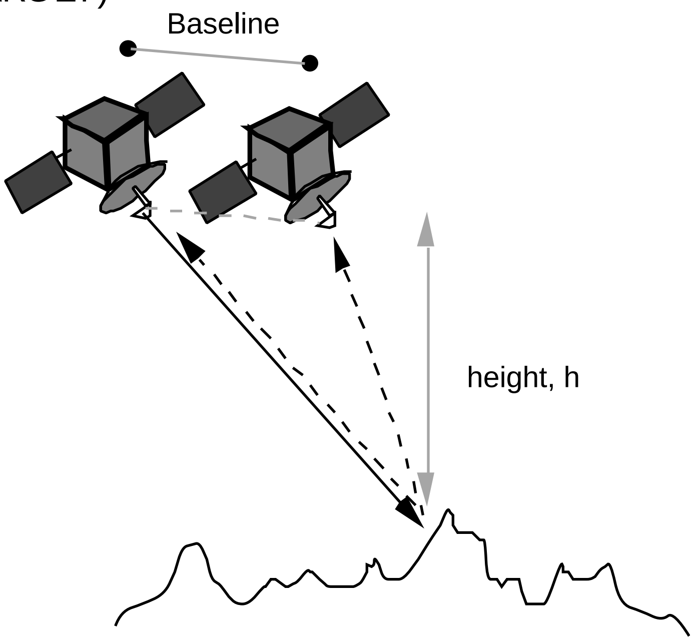
Radar Image

Imaging Radar Applications

- **INTERFEROMETRY**
  - USES THE PHASE DIFFERENCE BETWEEN TWO RADAR MEASUREMENTS TO DETERMINE TOPOGRAPHY (OR SPEED OF TARGET)

- TWO ANTENNAS, SEPARATED BY A KNOWN BASELINE (~ 1 --> 1000 METERS)
- MEASURE PHASE DIFFERENCE BETWEEN THE TWO BACKSCATTER MEASUREMENTS
- PHASE DIFFERENCE CAN BE RELATED TO DIFFERENCE IN RANGE BETWEEN TARGET AND RADAR ANTENNAS
- SOLVE FOR HEIGHT OF RADAR ABOVE EACH POINT ON GROUND
- IF PLATFORM ALTITUDE KNOWN

==> TOPOGRAPHY



- INTERFEROMETRIC MEASUREMENTS SEPARATED IN TIME (FEW DAYS –> 1 YEAR) CAN BE USED TO ESTIMATE SURFACE MOTION (BUT SIGNIFICANT SURFACE CHANGES CAN LEAD TO DECORRELATION ==> NO INTERFEROMETRY)

Shuttle Radar Topography Mission
Mapping the World in Three Dimensions

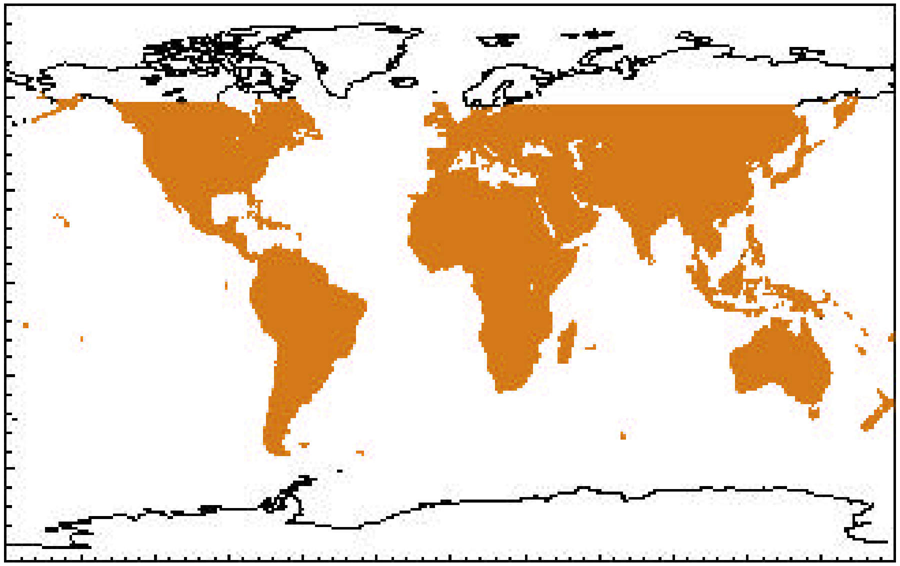
The Shuttle Radar Topography Mission (SRTM) will collect three-dimensional measurements of the Earth using imaging radar. The regions to be mapped are home to nearly 95 percent of the world's population.

Shuttle Radar Topography Mission
Objectives

During a single 11-day Space Shuttle flight, SRTM will produce:

- **A digital topographic map of 80% of Earth's land surace with:**
  - **30 meter horizontal resolution**
  - **10 meter relative height error**
  - **Globally consistent characteristics and datum**

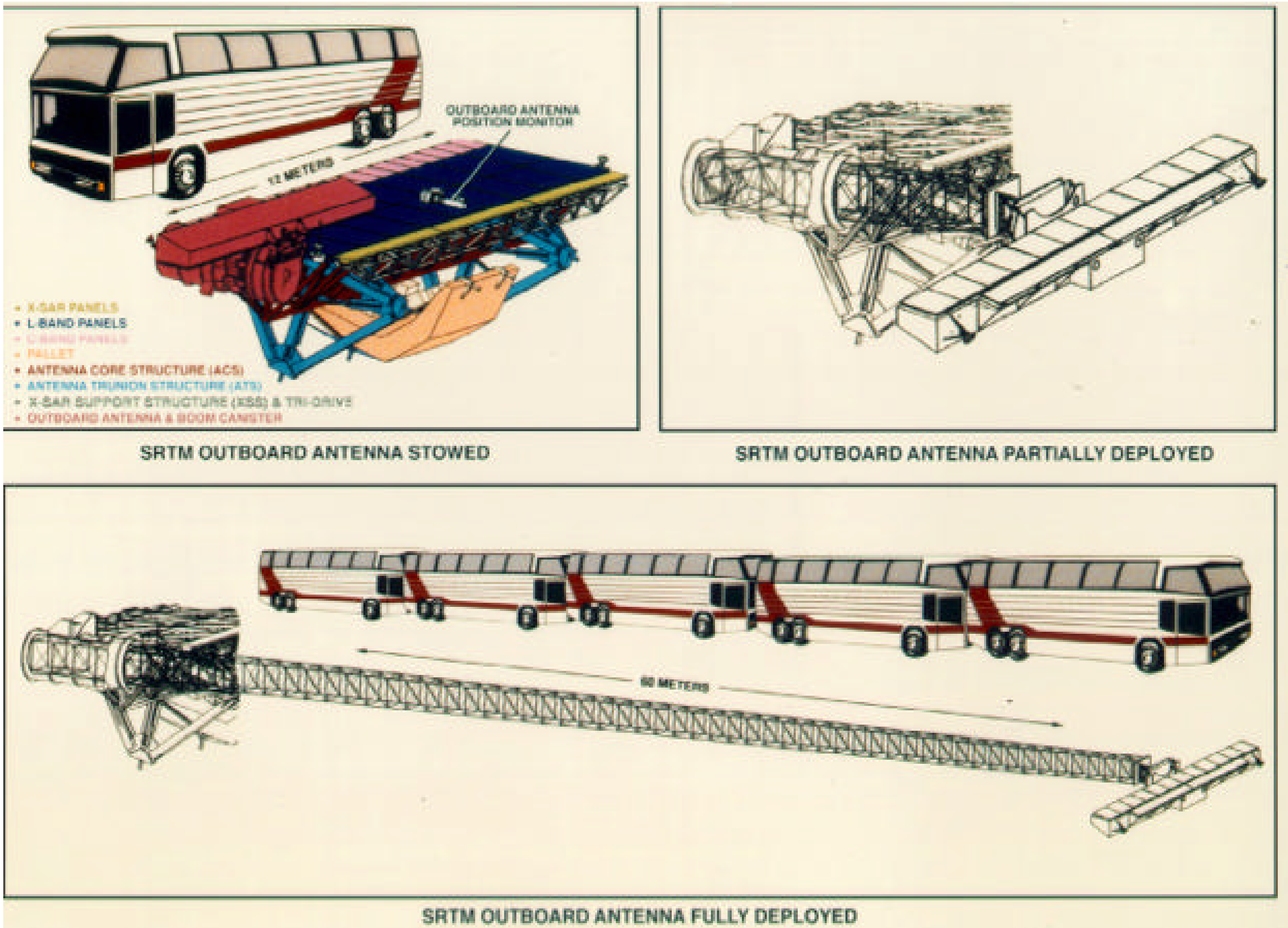
- **Rectified, terrain-corrected, mosaickable C-band radar image**



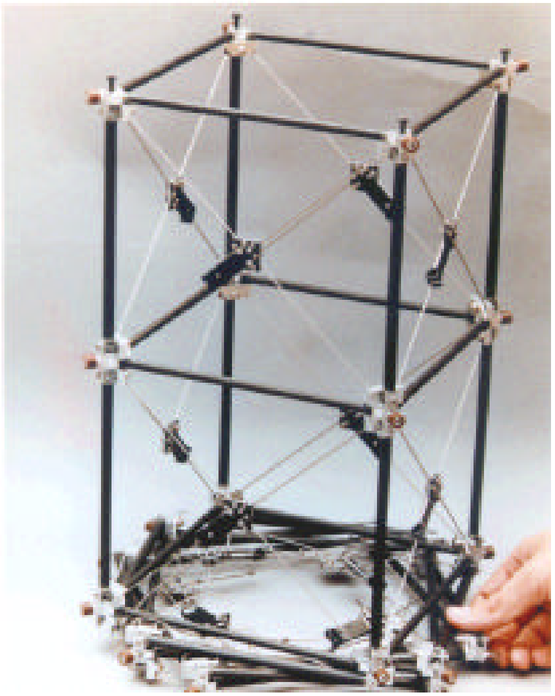
Shuttle Radar Topography Mission

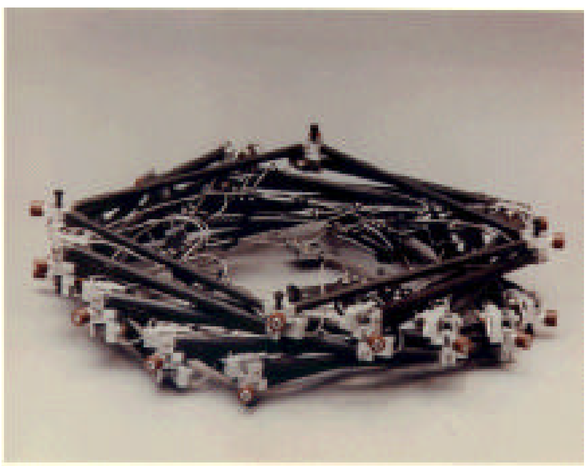
Shuttle Radar Topography Mission

Hardware

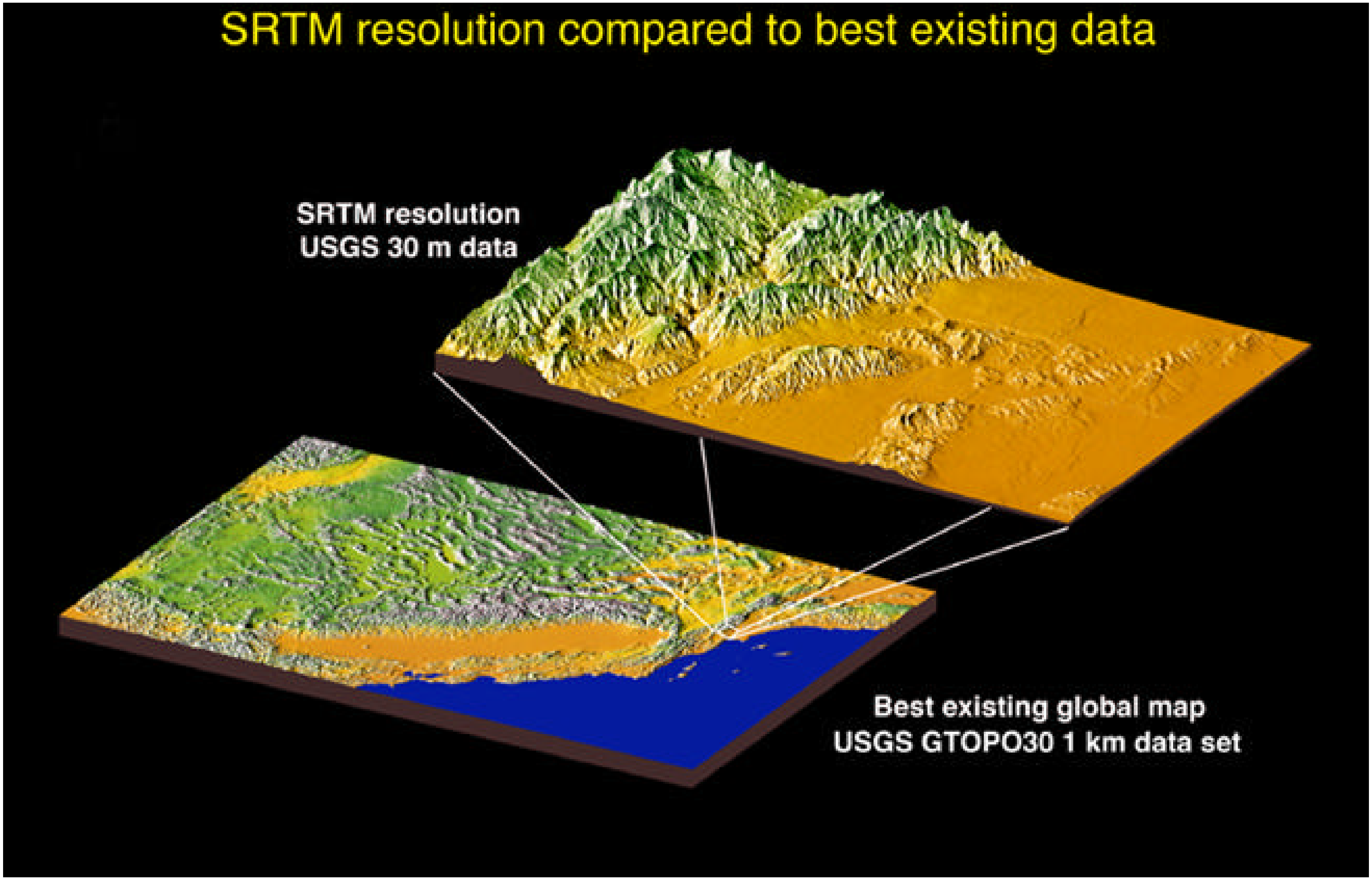


Shuttle Radar Topography Mission
MAST



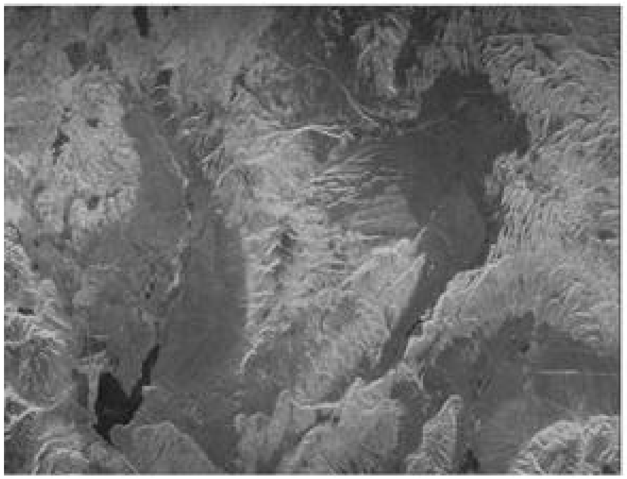


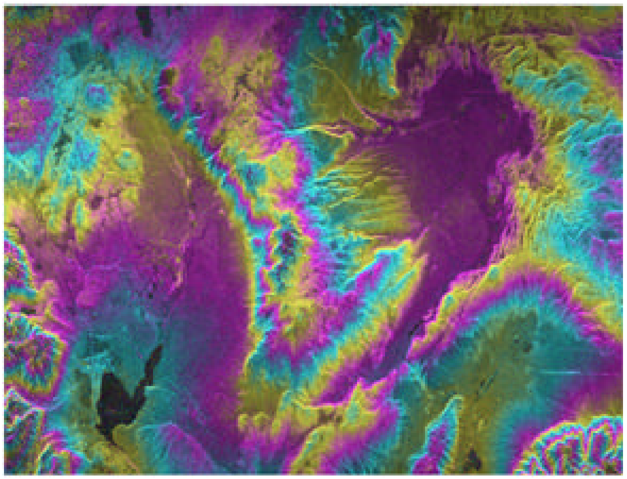
Shuttle Radar Topography Mission

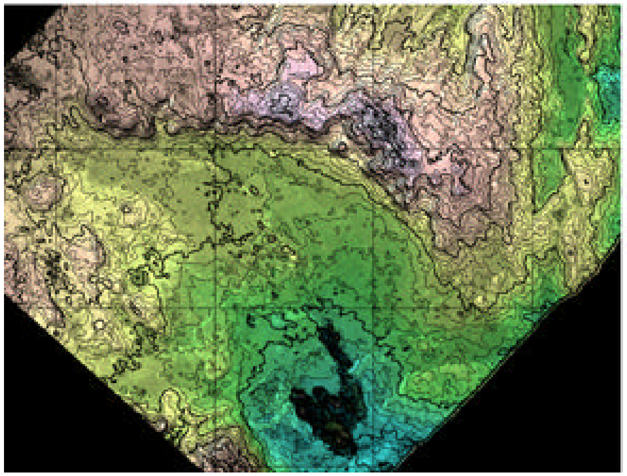


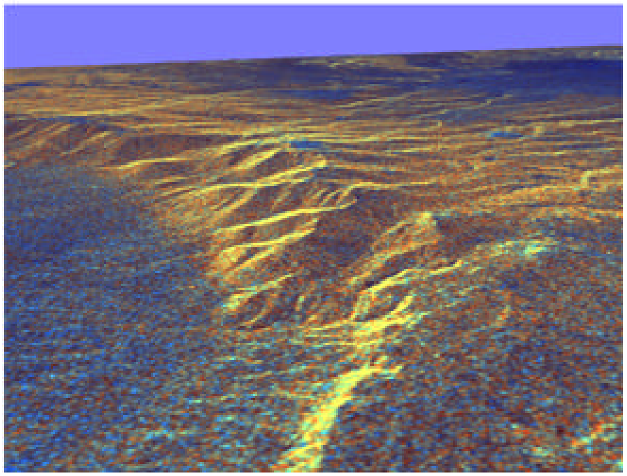
Shuttle Radar Topography Mission

Topographic Information Derived from SIR-C Interferometric SAR
Long Valley, California





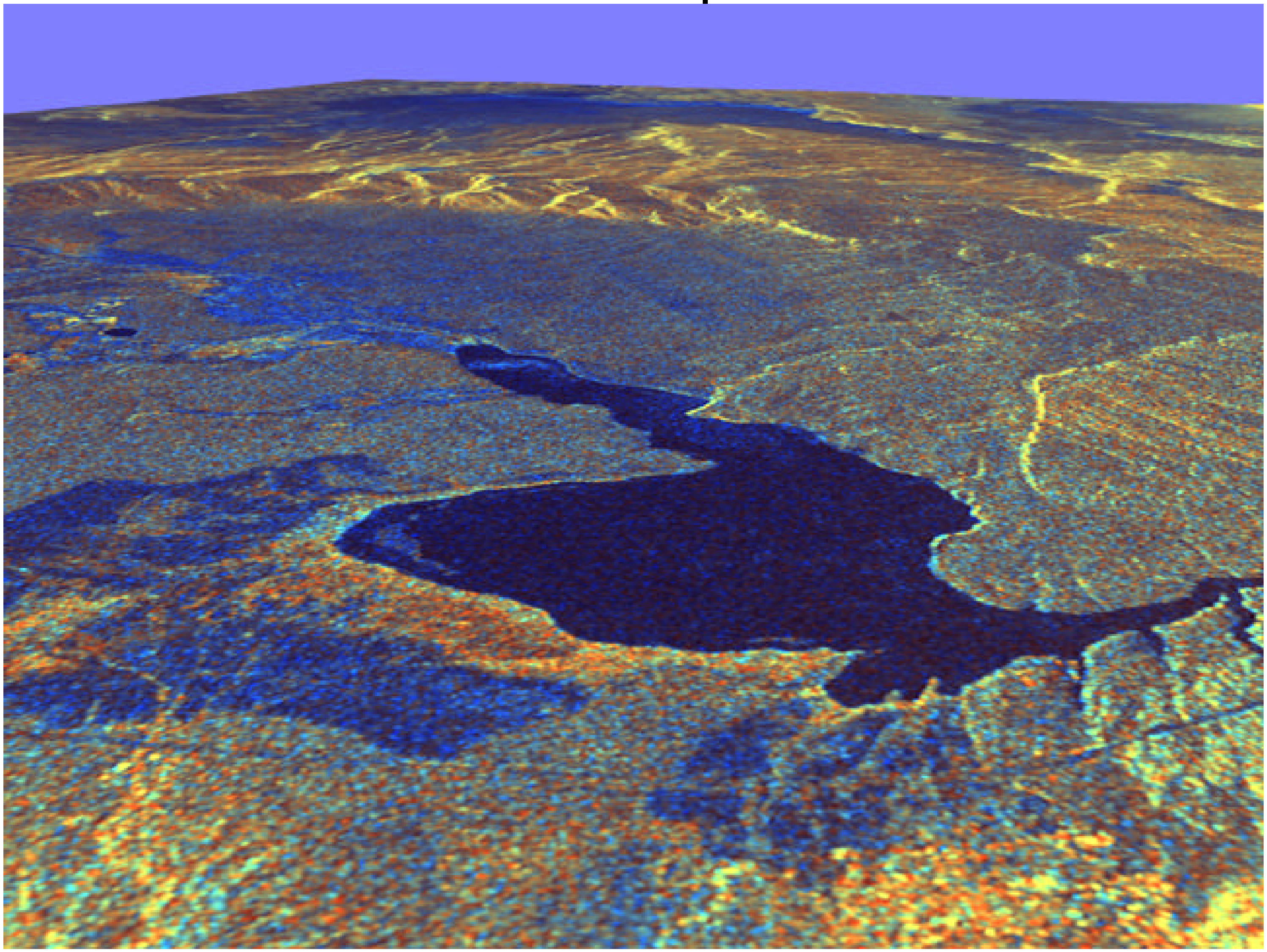




Shuttle Radar Topography Mission

Lake Crowley, California

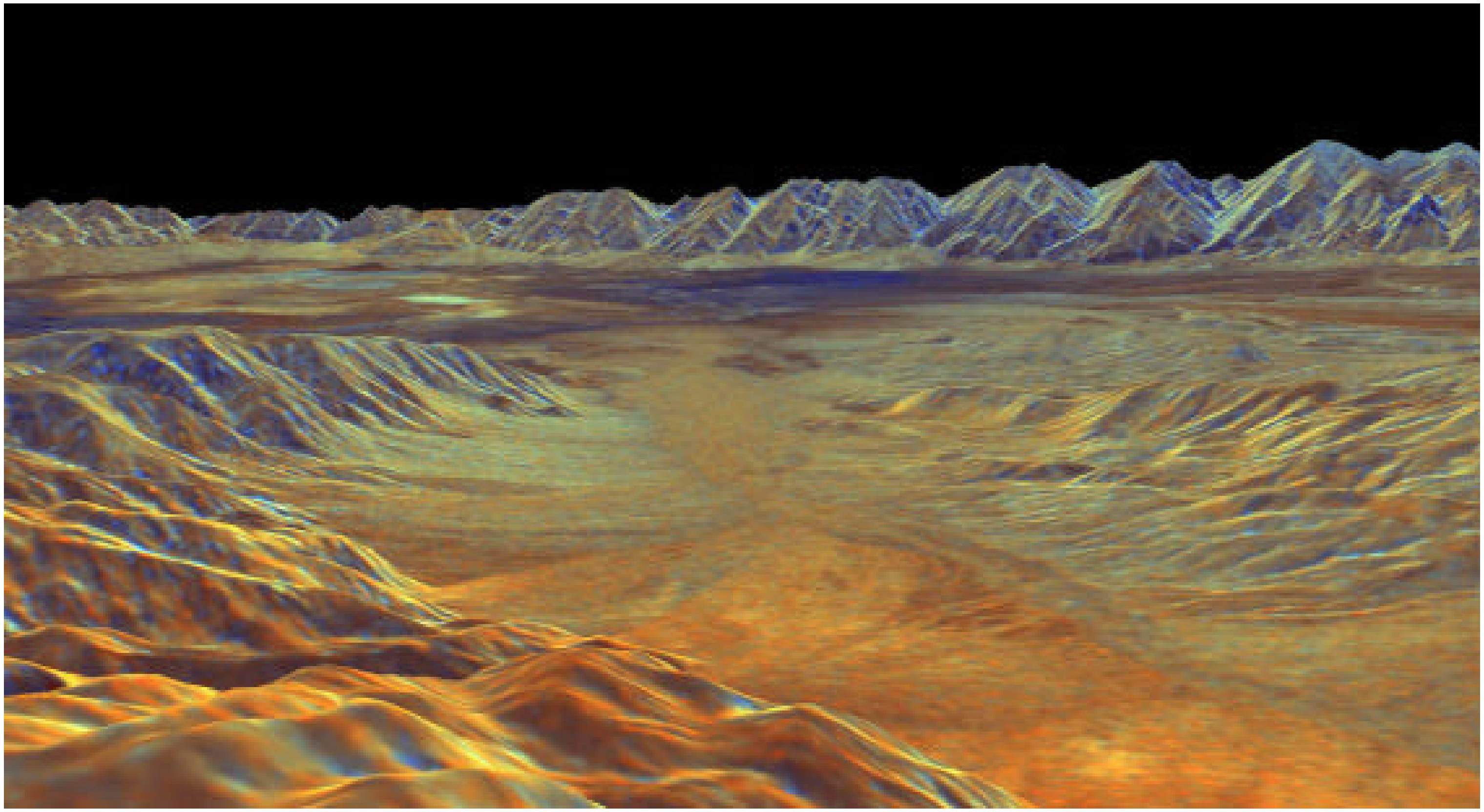
SIR-C/X-SAR 3-D Perpective View



Shuttle Radar Topography Mission

Saline Valley, California

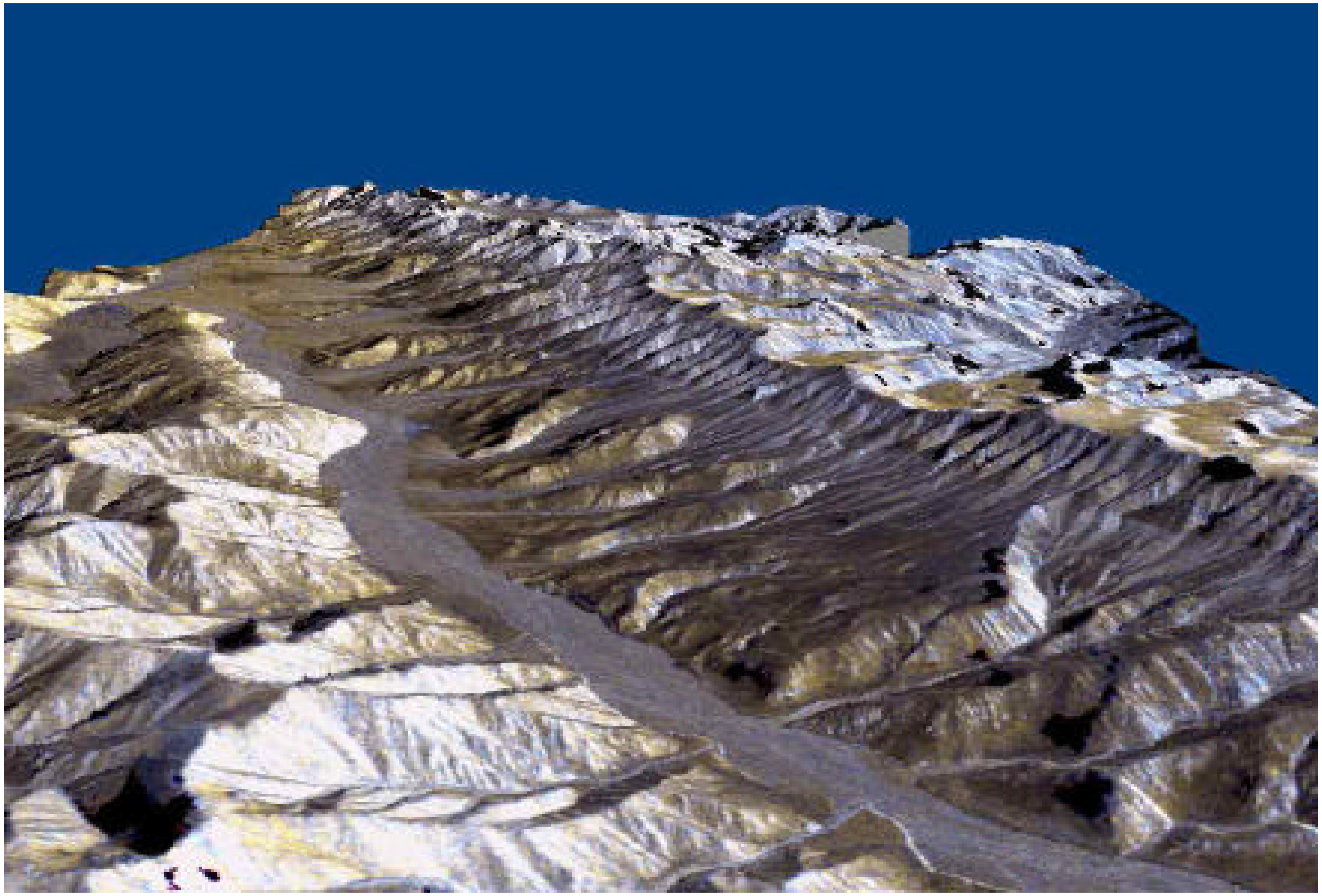
This image was created by overlaying radar image data onto a digital elevation model that was generated from two radar data sets. Through the technique of interferometry, the data sets are compared to obtain elevation information. Visualizations like this are helpful to scientists because they illustrate the relationships of different surface types, and show topographic features such as mountains and valleys. This image is representative of products which will be created from data obtained by the Shuttle Radar Topography Mission scheduled for launch in 2000.



Shuttle Radar Topography Mission

Karakax Valley, Western China

Scientists use visualizations like this for mapping common landforms in desert regions to learn more about Earth's past climate changes. This image is representative of products which will be created from data obtained by the Shuttle Radar Topography Mission scheduled for launch in 2000.



Shuttle Radar Topography Mission

Visit Our Website:
http://www.jpl.nasa.gov/srtm/